A staged replacement of the entire aorta from the ascending arch to the hypogastric arteries using a hybrid approach

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Combined open and endovascular hybrid procedures can be used to treat complex aortic pathology. This article reports a five-stage hybrid repair for a complex thoracoabdominal aneurysm with dissection in a 57-year-old man. To our knowledge, this is the first reported case of replacement and exclusion of the entire native human aorta from the root to the iliac bifurcations using a combined open and endovascular approach without neurologic complication. Bilateral hypogastric and femoral circulation was preserved. Aggressive spinal protective measures, including spinal drainage, motor-evoked potentials, and prevention of intraoperative and perioperative hypotension, were used during this staged approach. (J Vasc Surg 2008;48:1593-6.)

Since its initial description by Quinones-Baldrich et al[1] in 1999, the hybrid or combined open and endovascular approach to repairing complex thoracoabdominal aneurysms (TAAs) has enhanced our ability to treat this condition with morbidity and mortality rates comparable to open repair. We report a patient treated with a staged replacement of his entire native aorta from the aortic root to the hypogastric arteries using a combined open and endovascular technique.

CASE REPORT

A 57-year-old asymptomatic man presented with a chronic aortic dissection extending from the aortic root to the bilateral common iliac arteries. His aortic valve was resuspended and his ascending arch was repaired after an acute type A dissection 18 years ago at another hospital. He had a history of hypertension. His antihypertensive regimen consisted of metoprolol, hydralazine, and clonidine. He did not undergo formal genetic testing for Marfan disease or any other collagen vascular diseases. He denied any other medical conditions, and he was a nonsmoker. He had a noncontributory family history.

The patient was also found to have multiple aneurysmal aortoiliac segments involving his transverse arch, descending thoracic and infrarenal aorta, and left and right common iliac arteries. The diameters of these segments were 5.2, 5.0, 5.1, 3.0, and 2.5 cm, respectively. The innominate, left common carotid, and left subclavian, celiac, superior mesenteric, and left renal and right iliac arteries were supplied by the true lumen. The right renal and left iliac arteries were supplied by the larger false lumen (Figs 1 and 2).

The patient underwent a staged hybrid repair for his aortic pathology during a 2-year period. The first stage involved a redo sternotomy with replacement of the arch and proximal thoracic aorta using a 34-mm graft with placement of an 8-cm-long elephant trunk graft into the true lumen of the descending thoracic aorta. The distal portion of the elephant trunk graft would serve as the proximal landing zone for an endograft repair of his thoracic aneurysm.

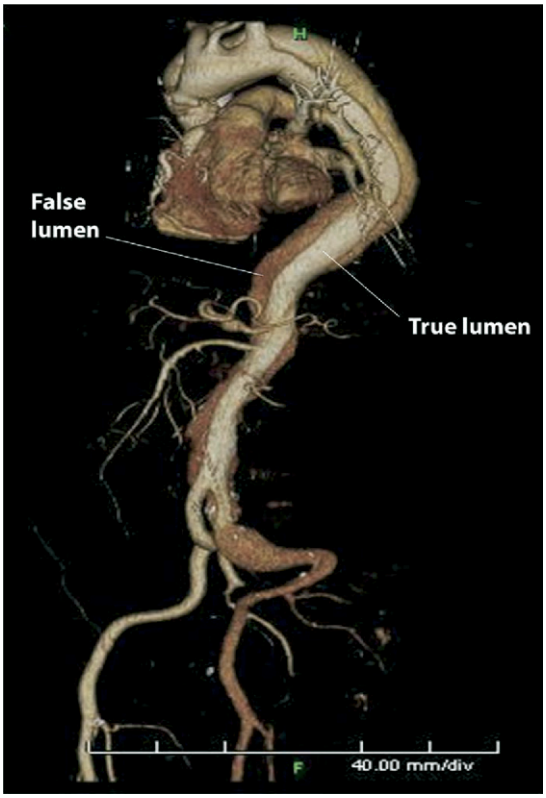

Fig 1. A computed tomography three-dimensional reconstruction of the patient's combined type A and B aortoiliac dissection before the hybrid repair. The innominate, left subclavian, left common carotid, celiac, superior mesenteric, left renal, and right iliac arteries arise from the true lumen. The right renal and left iliac arteries arise from the false lumen.

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Competition of interest: none.

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0741-5214/$34.00

doi:10.1016/j.jvs.2008.06.055

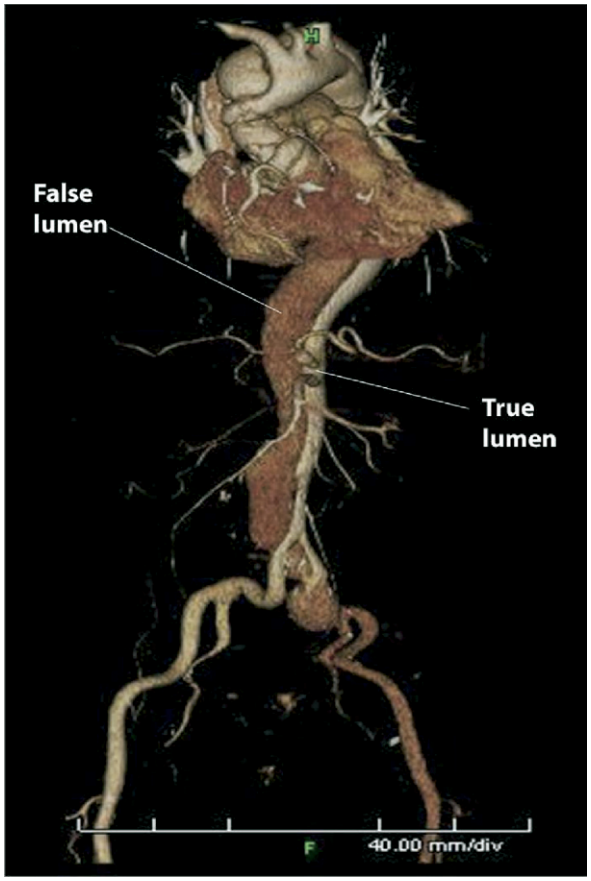

Fig 2. Three-dimensional view of the patient's initial computed tomography following 180-degree rotation demonstrates the false lumen and its branches. The right renal and left iliac arteries arise from the true lumen.

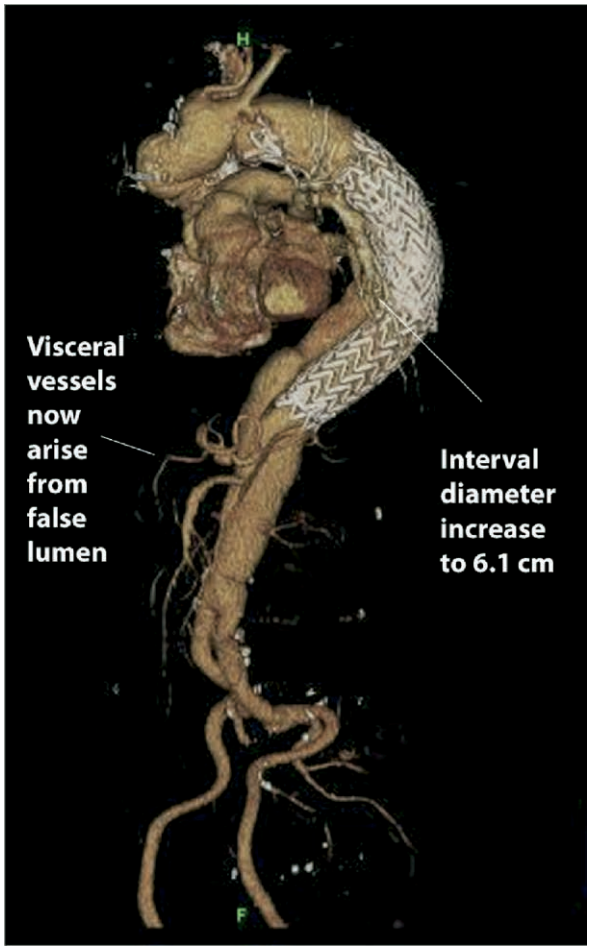

Fig 3. A computed tomography three-dimensional reconstruction after (1) repair of the aortic arch with elephant trunk procedure; (2) resection of the infrarenal abdominal aortic aneurysm and bilateral common iliac arteries and reconstruction with bifurcated Hemashield graft (Boston Scientific, Natick, Mass) to the iliac bifurcations; and (3) endograft placement in the true lumen of the descending thoracic aorta. Note that the celiac, superior mesenteric artery, and left renal arteries now arise from the false lumen after luminal shift secondary to endograft deployment. The diameter of the descending thoracic aorta increased in size from 4.6 to 6.1 cm in a 6-month period.

Three months later he underwent resection of his infrarenal abdominal aortic aneurysm and bilateral common iliac aneurysms using a 20- × 10-mm bifurcated graft through a left retroperitoneal approach. The aorta was fenestrated to the level of the infrarenal aortic clamp. A 10-mm graft conduit was sewn to the left limb, filled with heparinized saline, and tunneled in the retroperitoneum to the abdominal wall at the level of the inguinal ligament for access during later endograft placement.

Endovascular repair of the aneurysm and dissection in the descending thoracic aorta was undertaken 4 months later using two 40-mm × 20-cm TAG endografts (W. L. Gore & Associates, Flagstaff, Ariz). The prior elephant trunk graft was accessed. The proximal landing zone was just distal to the left subclavian artery, and the distal landing zone was 2 cm proximal to the celiac axis. The aortic diameter at the distal landing zone was used to size the TAG endograft at this level.

A completion angiogram demonstrated no evidence of endoleak and good perfusion of all the visceral arteries. Spinal drainage, motor-evoked potentials (MEPs), and avoidance of perioperative hypotension (mean arterial pressure >90 mm Hg) were used as measures for spinal protection. The spinal drain was maintained at a pressure of 10 mm Hg for 24 hours postoperatively during a period of neurologic monitoring. The drainage pressure was then raised to 20 mm Hg for 12 to 24 hours and then capped. No neurologic deficit was noted postoperatively, and the spinal drain was removed.

The patient remained asymptomatic; however, a computed tomography (CT) scan 6 months later demonstrated aneurysmal growth of the perivisceral aorta from a diameter of 4.6 to 6.1 cm. In addition, the celiac trunk, superior mesenteric, and left renal arteries, which had been supplied by the true lumen preoperatively, were now being perfused by a secondary false lumen with a compound dissection (Fig 3). The right renal artery also demonstrated persistent filling through a false lumen.

The rapid interval aneurysm expansion prompted debranching of the perivisceral aorta. An 8-mm graft was sutured end to side to

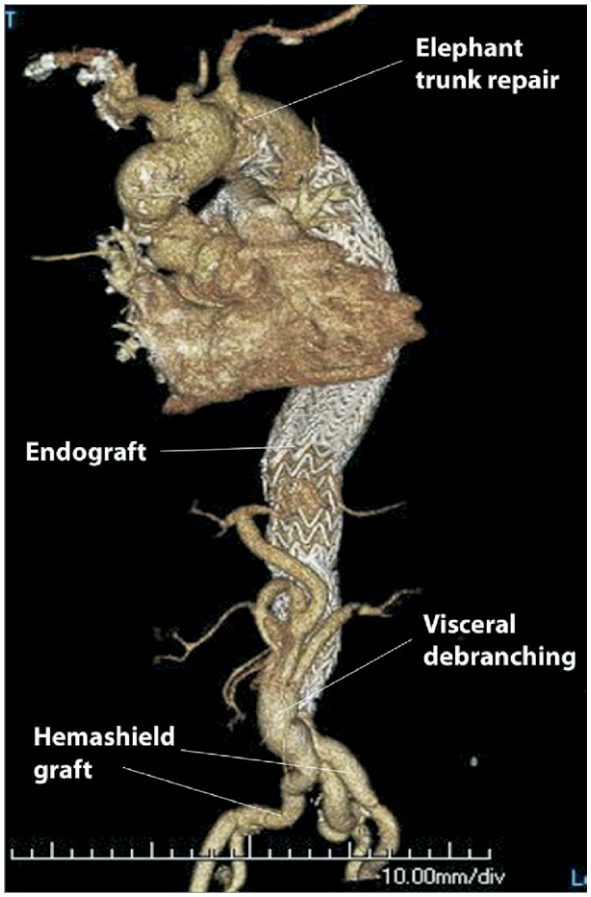

Fig 4. Final three-dimensional reconstruction after the five-stage hybrid repair. The entire native aorta from root to bilateral iliac bifurcations has been replaced with graft or endovascular stent graft, or both. No neurologic complications were observed.

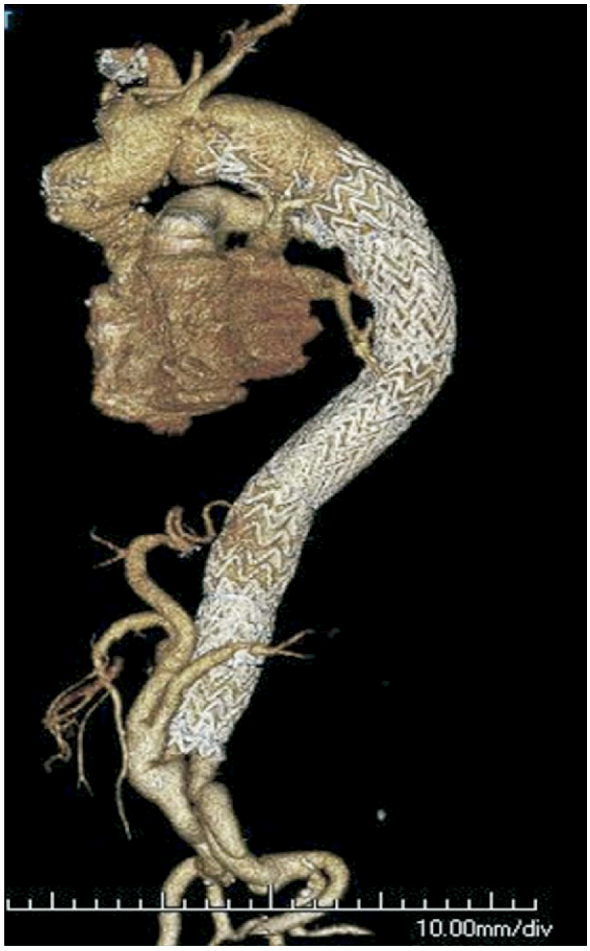

Fig 5. Rotational view of the final three-dimensional reconstruction demonstrates a lateral view of the patent visceral bypass grafts to bilateral renal arteries, the celiac trunk, and the superior mesenteric artery.

a 14- × 7-mm bifurcated Dacron graft. The right limb of the previously placed aortic bifurcation graft was used as the inflow, and bypasses were performed to the renal arteries, the superior mesenteric artery, and the common hepatic artery. The origins of these arteries were divided and oversewn. The previously placed conduit from the left graft limb was left in place for future endovascular access.

The patient had a stable postoperative course and was discharged on postoperative day 7. One month later, he underwent endovascular exclusion of the remaining debranched perivisceral aortic segment with a 40-mm and a 34-mm endograft as the final stage of the hybrid repair. The 34-mm endograft was landed in the prior 20-mm Hemashield graft (Boston Scientific Corp, Natick, Mass), which had dilated just proximal to its bifurcation. The prior conduit was used for access. Completion angiography demonstrated patency of the visceral and mesenteric bypass grafts, with no evidence of endoleak or persistent dissection.

He remained stable at 2 years after repair, without paralysis or neurologic deficit. A three-dimensional CT reconstruction at 28 months demonstrated no evidence of endoleak or aneurysm expansion (Figs 4 and 5).

DISCUSSION

To our knowledge, this is the first case report where replacement and exclusion of the entire native human aorta from the root to the iliac bifurcations with a combined open and endovascular approach was performed using this technique, without neurologic complication. A detailed timeline of all five stages is described in the Table. The combined hybrid approach for repair of a TAA was first described by Quinones-Baldrich et al[1] in 1999. Recent series have supported this approach with morbidity and mortality rates comparable to those reported for open thoracoabdominal aortic aneurysm (TAA) repair.[2,3] Similar cases have been included in series of both staged open and staged hybrid repair of TAA, where extensive areas of the thoracic and abdominal aorta were either covered or replaced.[4-7]

Our patient did not demonstrate any neurologic complications or paralysis during the 28-month follow-up period despite complete coverage of intercostal and lumbar collateral arteries. A more efficient, cost-effective procedure

Table. Details and timeline of five-stage hybrid repair

Stage	*Operation performed*	*Type of graft*	*Timeline*
1	Replacement of aortic arch, reimplantation of great vessels, fenestration of proximal descending thoracic aorta, placement of elephant trunk into true lumen of descending thoracic aorta	34-mm woven Dacron	0 months
2	Resection of infrarenal AAA, fenestration of infrarenal aorta, reconstruction with bifurcated graft to iliac bifurcations, placement of left iliac limb conduit	20- × 10-mm bifurcated knitted Dacron, 10-mm knitted Dacron conduit	5 months later
3	Placement of TAG[a] endograft in descending thoracic aorta, proximal landing zone at elephant trunk and distal landing zone proximal to celiac axis	Two 40-mm × 20-cm TAG endografts	4 months later
4	Visceral aortic debranching	14- × 7-mm knitted Dacron with 8-mm limb attached. 7-mm bypasses to bilateral renal arteries, 8 mm to celiac (retropancreatic) and 8 mm to SMA	7 months later
5	Placement of TAG endograft in abdominal aorta, proximal landing zone in prior endograft, distal landing zone proximal to visceral bypass	Proximal: 40-mm × 20-cm TAG endograft; distal: 34-mm × 20-cm TAG endograft	1 month later

AAA, Abdominal aortic aneurysm; *SMA,* superior mesenteric artery.
[a]W.L. Gore & Associates, Flagstaff, Ariz.

with fewer stages might have been performed with the combination of stages 2, 4 and 3, 5 (Table). It is likely that the staged nature of the repair contributed to preservation of spinal perfusion through collateral flow, although this conclusion is speculative.

Of note, spinal drainage and measurement of MEPs were used during both endograft procedures. Although the MEPs were stable throughout this repair, changes related to possible spinal ischemia would prompt the need for elevation of the blood pressure through the use of vasopressors or intravenous fluid administration, or both, to increase the spinal perfusion pressure. Drainage at a pressure of <10 mm Hg and reimplantation of lumbar arteries may also be indicated with MEP flattening.

Care was also taken to avoid intraoperative hypotension (mean arterial pressure >90 mm Hg) during and after all operations. In this patient, patent internal iliac and femoral arteries were maintained bilaterally, and perfusion to his anterior spinal artery was likely maintained through the vertebral arteries as well as the hypogastric and pelvic vascular collaterals. Care must be taken to avoid interruption of these plexuses when covering or replacing long segments of the thoracic and abdominal aorta.

A notable technical consideration became evident after endograft deployment in the true lumen of the supraceliac aortic dissection. Because of the small diameter of the true lumen, endograft constriction was present after deployment and required balloon dilatation of its entire length to restore normal distal perfusion. CT imaging 6 months postoperatively showed that the celiac artery, the superior mesenteric artery, and the left renal artery, which had been previously perfused by the true lumen, were now being perfused by the false lumen in the perivisceral aorta. This aortic segment increased in size from 4.6 to 6.1 cm during a 6-month period, which required subsequent treatment with debranching and endograft coverage. This was likely due to increased retrograde flow in the false lumen after endograft deployment and balloon dilatation of the true lumen during TAG placement. This complication should be considered in this clinical setting and perhaps fenestration should be avoided. The alternative to fenestration for renal artery perfusion would have been to bypass his right renal artery at the time of the infrarenal aortic aneurysm repair. Whether this would have prevented further enlargement of his perivisceral aneurysm is speculative.

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Submitted May 5, 2008; accepted Jun 23, 2008.